CIA/PB 131632-108

MARCH 4 1960

UNCLASSIFIED- INFORMATION ON SOVIET BLOC INTERNATIONAL GEOPHYSICAL COOPERATION - 1960

33 FDD

PB 131632-108

INFORMATION ON SOVIET BLOC INTERNATIONAL GEOPHYSICAL COOPERATION - 1960

March 4, 1960

U. S. DEPARTMENT OF COMMERCE
Business and Defense Services Administration
Office of Technical Services
Washington 25, D. C.

Published Weekly
Subscription Price $12.00 for the 1960 Series

Use of funds for printing this publication has been approved by the Director of the Bureau of the Budget, October 28, 1959

Approved For Release 1999/09/08 : CIA-RDP82-00141R000201080001-3

INTERNATIONAL GEOPHYSICAL COOPERATION PROGRAM -- SOVIET-BLOC ACTIVITIES

Table of Contents

Approved For Release 1999/09/08 : CIA-RDP82-00141R000201080001-3

I. ROCKETS AND ARTIFICIAL EARTH SATELLITES

Petrov Reports on Problems of Cosmic Velocities

The January 26 session of the All-Union Congress on Theoretical and Applied Mechanics was devoted to reports summing up attainments in various fields of mechanics.

Among the papers presented was one by Academician G. I. Petrov; it dealt with the problem of contending with the very great temperatures that arise on the surfaces of artificial bodies moving at great speeds. He pointed out that the continuing increase in speeds during flights in the atmosphere and the problem of the reentry of space vehicles can be solved only by the science of mechanics. His report also recommended the most rational forms for airships and the properties of materials that should be used in their construction. ("Mechanics and Problems of Cosmic Velocities," Izvestiya, 29 January 1960, p 6)

Polish Report on Soviet Cosmonaut Training

According to an article in a Polish periodical, "about 20 candidates have been undergoing space training in the USSR for about 2 years." Biological experiences from "laika," information from Sputnik III, and the lunar findings from the Soviet cosmic rockets have indicated that an average temperature of plus 20-30 degrees Centigrade can be successfully maintained in the cabin of a future space vehicle, even at a distance of 300,000 kilometers from the Earth.

Soviet scientists are quoted as saying that there is no problem of recovery of a cosmic rocket. Future Soviet cosmonauts, the article concludes, have already had intensive physical and psychic training under conditions similar to those they will encounter in interplanetary space.

The article contains illustrations of US and Soviet space vehicles. ("I'm Waiting for the Take-Off," by Jerzy Dagobert; Warsaw, Przyjaciel Zolnierza, 1-15 Dec. 1959, pp. 8-9)

Soviet Super Rockets Launched from Ust Urt Area Say Japanese

The following is a full translation of an article from the 2 February 1960 issue of Tokyo Shimbun on the possible launching site of the Soviet ballistic rocket fired on 20 January.

The Defense Agency, which had been investigating the performance and launching site of the Soviet ballistic rocket fired into the Central Pacific on 20 January, reached a temporary conclusion recently that the rocket apparently was fired from the vicinity of 55°E and 44°N in the Ust Urt area east of the Aral Sea.

The Soviet Union announced that the rocket hit within two kilometers of the target. It is a question, however, whether it was an "area." The Defense Agency made the delicate statement, "When we make calculations on the premise that the Soviet announced data are true, we reach the conclusion that the Soviet rocket was an excellent one fired at a 'point.' The performance, however, is accurate to an unbelievable extent."

The reason why, and the basic materials on the basis of which the Defense Agency reached this conclusion are: In the vicinities of the Caspian and Aral Seas which have been regarded by scientists of various countries as the possible rocket launching site, there are wide areas off-limits to foreign travelers. When the center line of the Soviet announced danger zone in the Pacific is extended, Kapustin Yar, north of the Caspian Sea, Ust Urt, east of the same sea, or Tyuratam, northeast of the Aral Sea, can be regarded as the probable launching sites. Taking into account the rocket's range and its flying time as well as the fact that the point of impact of the rocket moves eastward with the lapse of time owing to revolution of the earth, the authorities estimated the rocket's initial velocity, quadrant elevation and angle of direction as well as the point at which the rocket crosses the equator, assuming that the rocket was fired from each of these three areas.

As a result it has become clear that the trajectory of a rocket fired from the Ust Urt area will be closest to the center line of the off-limits area in the Pacific and will take a natural direction most suitable for the test. In that case, the rocket will fly 12,685.4 kilometers at a speed of 26,867 kilometers per hour. These figures somewhat differ from the data announced by the Soviet Union. The errors in this case, however, are smaller than those if the rocket were fired from the Tyuratam area or the Kapustin Yar area. In short, from the view that (1) the rocket trajectory is coincident with the center line of the off-limits area and (2) the rocket range figured out by Japanese authorities does not differ much from the Soviet announced figure, it is most reasonable to consider that the controversial Soviet rocket was fired from the vicinity of 55°E and 44°N in the Ust Urt area. The assumed maximum rate of climb and impact velocity of the rocket are about 7.25 kilometers and about 7.53 kilometers, respectively. These figures, too, are almost the same as the Soviet announced ones.

The Defense Agency says, "If the figures announced by the Soviet Union to date are correct, we may consider that the controversial Soviet rocket was even better than generally imagined and that it hit within two kilometers of the target 'point.'" The same agency, however, added "This is such an excellent performance that we can hardly regard it as possible technically."

The accuracy of fire of the controversial Soviet space rocket is about five thousandth in terms of that of the ICBM. Moreover, although the ICBM is a three-stage rocket, this space rocket is reported to be a two-stage rocket. It is surprising that this two-stage rocket showed such an excellent performance. However, the Defense Agency added that since it would conduct more detailed investigation, its calculations might undergo some changes. (Tokyo, Tokyo Shimbun, 2 Feb 1960).

Tokyo Reports Soviet Rocket Fired from Kapustin Yar

An item in the 30 Jan 1960 Tokyo Shimbun states that according to the most reliable information, the base for firing the large-model rocket into the Pacific Ocean by the Soviet Union is Kapustin Yar, southeast of Leninsk, located east of the Volga and 160 kilometers southeast of Stalingrad. The rocket's thrust, says the article, is believed to be about 800,000 pounds (about 363 tons). ("Base For Soviet Rocket Firing into Pacific Believed to be Located Southeast of Stalingrad"; Tokyo, Tokyo Shimbun, 30 Jan 1960, p 2)

II. UPPER ATMOSPHERE

An uncommon but interesting group among the galactic nebulae are the "comet" nebulae. Their distinguishing features are their external form (comet-shaped or cone-shaped) and their irregular brightness and structure. The bright part of "comet" nebulae usually has dimensions commensurable with the visible parts of large planetary nebulae. The star which causes their luminescence is usually one of low brightness, a fact difficult to reconcile with the presence of hydrogen emission lines in the spectra of some such nebulae.

The first to devote serious attention to this group of nebulae was V. A. Ambartsumyan. He demonstrated that the luminescence of these nebulae does not have a thermal nature. Subsequent research shows that the luminescence of "comet" nebulae may be caused by bremsstrahlung radiation of relativistic electrons in magnetic fields of such nebulae.

The present article cites some of the results of the author's research on this problem.

It can be shown that the nucleus of a "comet" nebula must possess a dipole magnetic field situated excentrically to the center of the star or a unipolar magnetic field (the latter possibility is difficult to reconcile with our present-day concepts of magnetism). The relativistic electrons, emitted from the region of the pole, can give synchrotronous radiation at great distances from the nucleus if the intensity of the magnetic field at the pole is on the order of 10^4 gauss.

The magnetic lines of force going out from the pole in the direction of the magnetic axis have the approximate form of straight rays. Electrons escaping from the pole at some angle to the lines of force will spin around them, describing a spiral trajectory. The radius of the trajectory should gradually increase the farther the electron is from the pole since the intensity of the field decreases with distance. The change in the radius means a change in the frequency of the relativistic electron. Therefore the electron radiates invisible ultrashort waves in regions close to the nucleus and invisible infrared and radiowaves in regions distant from the nucleus. Hence it follows that an electron with a given energy can give radiation in the optical range only at a certain distance from the nucleus.

The irregular changes in brightness and structure of "comet" nebulae have remained a mystery. The hypothesis of relativistic electrons, however, gives a simple and convincing explanation of this phenomenon. The picture of changing brightness and structure is still more pronounced if we also consider the effect of star rotation and the effect of possible variations in the intensity of the magnetic field.

The hypothesis of synchrotronous radiation of luminescence of "comet" nebulae also gives a satisfactory explanation of other phenomena, such as the formation of emission lines and absorption lines in their spectra. ("Synchrotronous Radiation in 'Comet' Nebulae," by G. A. Gurzadyan, Doklady Akademii Nauk SSSR, Vol 130, No 1, 1960, pp 47-50).

Gravitational Instability in Plane Rotating Systems

V. S. Safronov, of the O. Yu. Shmidt Institute of Earth Physics, has been actively engaged in the study of gravitational instability in plane rotating systems. He discusses his research in the recentmost issue of the Doklady of the Academy of Sciences of the USSR.

He begins by reviewing the work on this subject by Jeans (who published the classical treatment), the subsequent work by Chandrasekhar, and the contributions made still later by Bell and Schatzman. He points out the inadequacies in this work and the problems remaining unsolved.

The purpose of his paper is to find the value for the critical density for a real plane rotating cloud. Like other authors, he assumes that the axial symmetry of the cloud is constant and that the perturbations are therefore radial. He then discusses the derivation of equations applicable to gravitational instability and the value for the critical density necessary for gravitational instability under various conditions.

The minimum value for critical density, he finds, is more than 6 times greater than the value quoted by Bell and Schatzman for a two-dimensional case, and is greater than that found by Chandrasekhar. ("Concerning Gravitational Instability in Plane Rotating Systems with Axial Symmetry," by V. S. Safronov, Doklady Akademii Nauk SSSR, Vol 130, No 1, 1960, pp 53-56)

East German Exhibition Displays Radiotelescope Model

An exhibition marking the Tenth Anniversary of the founding of the German Democratic Republic was held in October 1959 on the grounds of the Exhibition of the Economic Achievements of the USSR in Moscow.

Among the exhibits which attracted especial attention were those displaying measuring instruments. Here were exhibited an instrument for measuring the intensity of the Earth's magnetic field within the range of 20 to 100 megacycles, and also a model of a radiotelescope which is located near Berlin. The latter has a diameter of 36 meters. ("Exhibition '10 Years of the GDR'"; Moscow, Radio, No 12, Dec 1959, p 17)

III. METEOROLOGY

Further Study of the Thermal Regime of the Upper Atmosphere

An unsigned article in the December 1959 issue of Meteorologiya i Gidrologiya discusses the thermal regime of the upper atmosphere, for which so much new data has been collected from rockets and artificial earth satellites.

The principle purpose of the article is to discuss the results of theoretical (and to a small extent, experimental) research on factors determining the vertical distribution of temperature in the upper atmosphere. Each layer of the atmosphere is treated separately. There are 5 figures, 2 tables, and a bibliography of over 40 items cross-referenced in the text. This 7-page article can give only a cursory treatment of this subject, but it makes clear the great strides made during the last few years in our knowledge of this subject, and points out that much which was accepted as true a short time ago has now been proven incorrect. ("Concerning the Theory of the Thermal Regime of the Upper Atmosphere," Meteorologiya i Gidrologiya, No 12, Dec 1959, pp 41-47)

Novosibirsk Affiliate of the Institute of Aeroclimatology

One of the new scientific institutions of Novosibirsk is the affiliate of the Scientific Research Institute of Aeroclimatology. It is located in a specially-built 3-story building.

"Into our institute," said Yuriy Sergeyevich Chernov, director of the affiliate, "come the materials of observations on climate from all of the aerometeorological stations of the country. Their processing is fully mechanized. Scientists are engaged in the study of climate in all points of the Soviet Union, and especially in Siberia and the Far East."

"Now, in the affiliate, the installation of the latest analytical computers and other machines is being conducted at an accelerated pace."

("Novosibirsk Affiliate of the Institute of Aeroclimatology"; Moscow, Izvestiya, 3 Feb 1960, p 3)

IV. GRAVIMETRY

Measurements at Sea with the "GAL" Gravimeter

This is the complete translation of an article setting forth the results of gravimetric measurements at sea aboard a ship of about 6,000 tons displacement. The mean square error of observation points varies between ±3.5 and ±14.0 mgl, depending on the values for perturbing accelerations.

From February through June 1958 research was carried on for determination of the force of gravity at sea; the instruments used were three gravimeters and a RNU-IV instrument developed at the Aerogravimetric Laboratory of the Institute of Earth Physics of the Academy of Sciences of the USSR. For check measurements the instrument used was a four-pendulum marine instrument manufactured in the scientific research experimental workshops of the Central Scientific Research Institute of Geodesy, Aerial Surveying and Cartography (TsNIIGAiK) from a land-type instrument of the kind developed by L. V. Sorokin. Points at sea were determined by two gravimeters because there were only two attachments. Observations were conducted at sea and in port aboard a ship of about 6,000 tons displacement.

There were heavy seas during the ocean voyage. Inasmuch as the background of perturbing accelerations was very intense (an average of about 100-200 gl) it was impossible to process the gravimeter recordings.

However, observations with the instruments under such severe conditions was a good test of their quality of construction. It should be noted that the gravimeters did not fail once during the time of the voyage. As will be seen below, they maintained their constancy well.

Observations in gulfs, bays, harbors, etc., were made while the ship was moving under different conditions: when the ship was moored and in a roadstead, drifting in the ice, or moving through the sea or straits under different kinds of wave action and at various speeds. During the entire voyage recordings of gravimeter readings were made continuously on slow-speed reels of photopaper moving at the rate of 11.2 mm per hour. In those cases when the ship was able to reduce speed and hold strictly to course specifically for gravimetric measurements, the recording on the slow-speed reels of photopaper was suspended and these recordings were made on high-speed reels of photopaper with the film moving at the rate of 13.4 mm/min. The registration of perturbing accelerations and inclinations was usually made simultaneously with the recording of gravimeter readings on high-speed reels of photopaper, but this was not successful in all cases. Attempts to make observations at sea with the four-pendulum instrument proved unsuccessful due to the strong oscillation of the pendulums. When the ship was at anchor in port joint observations were made with the gravimeters and the four-pendulum marine instrument. The results of these observations were used to determine the values for a unit division in the gravimeter records. Port observations that were tied in to the land network of gravimetric control points were used as initial gravimetric points for the observations made at sea.

The processing of gravimetric observations made at sea was accomplished using the formula:

$$\Delta g = \Delta g_{m_{cp}} - \Delta g_{\ddot{x}\ddot{y}} \pm \Delta g_{э}, \tag{1}$$

where Δg -- the difference in the values of acceleration in force of gravity between points at sea and land control points.

The terms of the right part of formula (1) were determined in the following way:

First term:

$$\Delta g_{m_{cp}} = \frac{\sum_{1}^{n} \left[K\Delta m - Kc\Delta h + \frac{\varepsilon a R \cdot 10^{3} \, (m_K - m_H)}{t_K - t_H} \right]}{n}, \tag{2}$$

CPYRGHT

where n — the number of gravimeters used; K — the value for a graduation of the gravimeter in mgl/mm; $\Delta m = m - m_o$ — the difference in the mean readings of the gravimeter at the point in question and at the land control point (mm); c — the hourly displacement of the null point of the gravimeter (mm/hr); Δh — the time from departure from the initial point (hours); ε — the coefficient of damping of the suspension system (1/sec); a — the pendulum bar (cm); $R \approx 12 \cdot 10^{-5}$ — the constant of the reading device (1/mm); m_K and m_H — the averaged readings at the end and beginning of recording; t_K and t_H — the time at the end and beginning of recording.

Table 1 shows the values for K, determined from the various differences of Δg during the voyage. The Δg differences Nos. 1-7 were determined with a four-pendulum marine instrument, while differences 8-9 were recorded when tying in the points of observation and gravimetric control points.

The settings of the instruments were changed twice during the period of observations. Values 1 and 8 were recorded before the instruments were reset; Nos. 2 and 3, after the first resetting, Nos. 4-7 and 9, after the second. The gravimeters were removed from the ship when determining values 8 and 9. Table 1 shows that the deviation of the value of a graduation of the three instruments from their mean has a systematic character for each difference. This permits us to assume that the constancy of the value of the graduations of the instruments can be greater than the accuracy with which their mean value was determined; this is because an error in determining the value of a graduation could be introduced by inaccuracy in the differences of Δg determined by the four-pendulum instrument, or by some other factor not associated with the design of the gravimeters.

During the entire period of observation the ship was unable to visit the same port twice; therefore the displacement of the null point of the gravimeters was determined from the change in their readings during the time of stopovers in ports at different times on the voyage. The results of these determinations are given in the table. Inasmuch as the stopovers were of short duration and the gravimeter readings changed little, the accuracy of an individual determination was limited by errors in reading during the measurement of the recordings. Therefore when computing the mean weights for each determination we assigned a weight proportional to the duration of observations. The first observation was begun soon after readjustment of the settings of the instruments and changes in the thermostat temperatures from $+25^{\circ}$ to $+35^{\circ}$; the second observation — after the second readjustment of the setting. Table 2 shows that deviations of the values for displacement of the null point from the mean (if we ignore the first value for instrument No. 3) lie in the limits of possible error in determination and in general are of an accidental character. It is therefore possible to assume that the variation in displacement did not exceed $\pm$8-10% of the mean value in the course of the entire voyage.

The coefficient of damping of the gravimeters is $\varepsilon \approx 5000$ 1/sec. Such a degree of damping reduced the background of perturbing vertical accelerations (with a period on the order of 8 seconds) on the instrument recordings by approximately 100 times. Phase and amplitude distortions, appearing during observations at the time of movement of the ship and allowed for by the term

$$\frac{\varepsilon aR \cdot 10^3 \, (m_K - m_H)}{t_K - t_H}$$

were almost unnoticeable with the degree of damping and ship speed indicated.

The second term:

$$\Delta g_{\ddot{x}\ddot{y}} = \frac{\ddot{x}^2 + \ddot{y}^2}{2g} \qquad (3)$$

is a correction for horizontal acceleration. Here $\ddot{x}$, $\ddot{y}$ are horizontal accelerations (in mgl) corresponding to side and bottom surfaces of the ship, received as a result of processing the records of the RNU-IV instrument. The processing of the records of the RNU-IV instrument in port showed that in an overwhelming majority of cases the correction $\Delta g_{\ddot{x}\ddot{y}}$ does not exceed 4-5 mgl. Inasmuch as the number of records of the RNU-IV instrument was less than the number of observations with gravimeters suitable for processing and the records made in a number of cases do not coincide in time, corrections for the influence of horizontal accelerations were not introduced, but were taken into account when evaluating accuracy.

The third term:

$$\Delta g_{э} = 7.5 v \sin A \cdot \cos \varphi, \qquad (4)$$

where $\Delta g_{э}$ is the correction for the Eötvös effect (mgl); v — the speed of the ship (knots); A — the direction of movement (true course of the ship); φ— the latitude of the place. The value of the correction for the Eötvös effect did not exceed 60 mgl. The maximum speed of movement of the ship was 13 knots. The accuracy of the determinations by the gravimeters can be evaluated in the following ways.

Evaluation of errors in determination of the terms of formula (4) and determination of the total error in the results. Considering the errors to be accidental and the instruments equally precise, we can write:

$$\sigma_{\Delta g} = \pm \sqrt{\frac{\sigma_{\Delta m}^2 + \sigma_K^2 + \sigma_c^2}{n} + \sigma_{\ddot{x}\ddot{y}}^2 + \sigma_{э}^2}\,, \qquad (5)$$

where $\sigma_{\Delta g}$ — the total mean square error of the difference in Δg (mgl); $\sigma_{\Delta m}$ — the mean square error in the reading (measurements of the recordings on the film) (mgl); σ_K -- the mean square error due to inaccuracy in the value of the graduation of the gravimeter (mgl); σ_c — the mean square error in the correction for displacement of the null point (mgl); $\sigma_{\ddot{x}\ddot{y}}$ -- the mean square error in the correction for the influence of horizontal acceleration (mgl); $\sigma_э$ -- the mean square error in the correction for the Eötvös effect (mgl).

To evaluate the values for the errors in reading we selected four recordings made under different conditions, each processed by four operators by means of a millimeter grid drawn on a glass plate. The first recording was made on a slow-speed photopaper reel when the ship was at anchor in port (point of departure); the second — also on a slow-speed photopaper reel, while the ship was in movement; the third and fourth recordings — on high-speed photopaper reels when the ship was travelling through light and heavy seas, respectively. The recordings were evaluated by eye. The operator made measurements in 18 places on each recording. The results of this evaluation are given in Table 3.

The error in reading is $\sigma_{\Delta m} = \sqrt{\sigma_{m_o}^2 + \sigma_m^2}$ (where σ_{m_o} and σ_m, respectively, are errors in measurement at the point of departure and a point at sea). On the basis of the resulting data the error in reading on the average can be taken as equal to $\sigma_{\Delta m} = \pm 3.5$-4 mgl.

Errors in determination of the value of a graduation of the instruments are given in Table 1. The error σ_K when determining the maximum Δg (450 mgl) by one instrument in the cited observations can attain ± 7.0 mgl. As a mean we can use $\sigma_K = \pm 4$-5 mgl.

Errors in determination of displacement of the null point of the instruments are given in Table 2. The error σ_c for these values for a 25-day period for one instrument does not exceed ± 5 mgl. For an average we can use $\sigma_c = \pm 3$-4 mgl. Evidently a longer period of shore observations for the determination of c or the return of the ship to the point of departure permits us to substantially decrease the error σ_c.

The error $\sigma_{\ddot{x}\ddot{y}}$ can be used as equal to the mean value of the correction for the influence of horizontal accelerations, inasmuch as the latter was not introduced, -- $\sigma_{\ddot{x}\ddot{y}} \approx 4$-5 mgl.

The point location of the ship at the time of observations was determined by the method of intersection on shore features; therefore it was possible to precisely determine the true speed and true course of the ship. Determination of the velocity and course was checked against the records of the pilot and course indicator (gyrocompass). The average $\sigma_э$ can be considered equal to ± 3 mgl.

On the basis of the evaluations made, the total error will equal, for points at sea (two instruments) an average of $\sigma_{\Delta g} = \pm 7$-8 mgl, and for shore points (three instruments) — $\sigma_{\Delta g} = \pm 3.5$ mgl. The accuracy of one instrument when determining a shore point may be regarded as equal to ± 5.6 mgl.

Intercomparison of the results of observations with gravimeters. We calculated the mean square errors by using formulas for the determination of errors using a series of uniform double measurements. The computations were made for points determined in ports, for the entire group of points at sea, and for the most characteristic sectors of the cruise.

A summary of the results is given in Table 4.

Comparison of the results of observations with gravimeters and the four-pendulum instrument. The convergence of the gravimetric and pendulum determinations is characterized by a scattering of the values for the graduations (Table 1). For a more graphic evaluation we calculated Δg from the readings of the gravimeters and made a comparison with Δg, determined by the pendulum instrument (Table 5). When computing the errors we made the assumption that the accuracy of determination of Δg with the four-pendulum instrument and the set of gravimeters was identical.

Comparison of the results of observations in sections of the route covered twice. Points were selected whose coordinates were at least 3' apart in latitude and 5' in longitude. The results are given in Table 6.

A summary of the results of evaluation of the accuracy by four independent methods is given in Table 7.

The data in Table 7 show that the results of independent methods of evaluation are in good agreement and evidently characterize the true accuracy of the gravimeters.

Based on the experience of this gravimetric survey, it seems possible to express the following ideas concerning the accuracy, possible utilization and possibilities for improvement of the "GAL" gravimeters. It has been shown that the present models of "GAL" gravimeters can be used for a survey with an accuracy of ± 7-8 mgl and above on surface vessels and submarines when perturbing accelerations are no more than 10 gl. The duration of the voyage, without return to the point of departure, in this case can last 25-30 days. In this case if it is possible to first determine the value of a graduation of the gravimeters, then the conduct of the gravimetric survey under such conditions can be accomplished with gravimeters alone — without using pendulum instruments. To increase the accuracy it is above all necessary to increase the accuracy of determination of the value of the graduation and displacement of the null point, and also accuracy in maintenance of the constancy of these values during the course of observations.

For small perturbing accelerations at the time of smooth and straight-line movement of the ship, "GAL" gravimeters can be used for the uninterrupted recording of gravimetric profiles. Observations in all cases should be conducted by a group of instruments (not less than three gravimeters).

The first step in the modernization of "GAL" gravimeters for use at sea on surface vessels (when the perturbing acceleration averages 60-80 gl), should be a considerable increase in the damping of the suspension system.

Table 1

No. of point	Standard Δg, mgl	K_1, mgl/mm	Deviation from mean	K_2, mgl/mm	Deviation from mean	K_3, mgl/mm	Deviation from mean
1	97	7.98	-0.57	11.69	-0.70	10.78	-0.56
2	188	-	-	12.88	+0.49	11.53	+0.19
3	220	8.92	+0.37	13.29	+0.90	12.02	+0.68
4	50	(9.10)	(+0.55)	11.76	-0.63	10.76	-0.58
5	271	-		12.21	-0.18	11.04	-0.30
6	221	-		12.14	-0.25	11.19	-0.15
7	103	-		12.48	+0.09	11.77	+0.43
8	105	8.64	+0.09	12.65	+0.26	11.67	+0.33
9	98	8.13	-0.42	12.48	+0.09	11.26	-0.08
Mean		8.55		12.39		11.34	
Mean square error in mean, %		±0.22 ±2.6%		±0.17 ±1.4%		±0.15 ±1.3%	

Table 2

No. of observations	Duration, days	24 K_1C_1 mgl/day	Error in individual determination, %	24 K_2C_2 mgl/day	Error in individual determination, %	24 K_3C_3 mgl/day	Error in individual determination, %
1	3.5-4	4.98	±5	1.54	±20	(5.08)	±6.3
2	5-6	4.18	4	1.54	12.5	3.48	5.9
3	8.7	3.96	2.5	2.08	7	3.37	3.9
4	17	4.02	1.5	1.72	3.7	3.04	2.2
Mean weight		4.15		1.75		3.43	
Mean square error of mean, %		±5		±8.5		±11.1	

Table 3

No. of recording	Mean square error, mgl	No. of recording	Mean square error, mgl
1 (at point of departure)	±0.99	3	2.94
2	3.72	4	5.59

Table 4

No. of point	Points used in processing	No. of points	Systematic part, in mgl	Mean square error, mgl
1	Points determined in port	6	+1	± 2.6
2	All points at sea	126	-2	± 8.0
3	Points at sea, while moving through ice	19	+2	± 2.8
4	Points at sea, waves up to category 4			
	Route sector a	21	-4	± 5.8
	Route sector b	10	+5	± 2.7
	Route sector c	20	+5	± 4.6
5	Same, waves up to category 2			
	Route sector a	25	-7	± 6.0
	Route sector b	6	+5	± 8.4
6	Points at sea, after arriving on high seas	14	-13	±14.0

Table 5

No. of point	$\Delta g_{pendulum}$, mgl	$\Delta g_{pendulum} - \Delta g_{mean\ gravimeter}$, mgl
1	97	- 6
2	188	+ 5
3	220	+12
4	50	- 1
5	271	- 5
6	221	- 3
7	103	- 1
Mean square error in one measurement using set of gravimeters		± 4.1

Table 6

Repeated points	Difference in values of g_H, in mgl
1st pair	- 3
2d pair	- 3
3d pair	+ 4
4th pair	0
5th pair	+24
6th pair	- 2
Mean square error in one measurement, with set of gravimeters	± 7.2

Table 7

Method of evaluating accuracy	Mean square error of one measurement with set of gravimeters, in mgl	
	When stopping in port (set of 3 instruments)	At sea (set of 2 instruments)
Sum of errors in reading and determining constants of gravimeters and errors in introduced corrections	±3.5	±7.8
Comparison of results of simultaneous observations with gravimeters	±2.6	±8.0
Comparison of results of observations with set of gravimeters and four-pendulum instrument	±4.1	-
Comparison of repeated observations with set of gravimeters	-	±7.2

("Measurements at Sea with the 'GAL' Gravimeter," Ye. I. Popov, Izvestiya Akademii Nauk SSSR, Seriya Geofizicheskaya, No 12, Dec 1959, pp 1793-1798)

V. SEISMOLOGY

Seismic Research in the Kansu Corridor

This is a complete translation of a paper by B. A. Petrushevskiy describing the seismic-geologic conditions in the Kansu Corridor (Northwestern China), visited by the author late in 1958.

In 1958 D. A. Kharin, N. V. Shebalin and the author were sent to the Chinese People's Republic by the Institute of Earth Physics of the Academy of Sciences of the USSR to participate in a plan for Soviet-Chinese research on seismic activity in the Chinese People's Republic and to render scientific assistance on several problems associated with this research. The general position of seismology in China and its progress in recent years has been treated elsewhere (Izvestiya AN SSSR, Seriya Geofizicheskaya, No 1, 1957 and No 6, 1958). In this article the author desires to dwell on regional seismic research, a new activity for the Institute of Geophysics and Meteorology of the Academy of Sciences of the Chinese People's Republic; the author also wishes to examine the seismic and geologic conditions of a region selected by Chinese scientists as a primary subject for investigation and express some ideas relative to the research program.

At the present time Chinese seismology must as quickly as possible solve one of the most complex problems of seismology — the prediction of the time and place of earthquake occurrence. To accomplish this the plan calls for the detailed study of the seismicity of a number of regions known for their high degree of seismic activity, and in particular, the so-called Kansu Corridor in northwestern China. We visited this region in the company of Chinese scholars and made several field trips (in part seismological and geological, in part geological alone). As a result of these field trips, and after an analysis of existing data on the geological structure and seismicity of the Kansu Corridor, we managed to get a rough idea of its seismic-geologic conditions. Benefiting by the experience of similar work in the USSR, we were able to make some recommendations as to the directions such research should follow. These recommendations were then left in written form at the Institute of Geophysics and Meteorology of the Academy of Sciences of the Chinese People's Republic; after a thorough discussion with Chinese scholars these recommendations were all adopted. This article (with small changes) was written on the basis of those recommendations.

Geological Conditions of the Region

The term "Kansu Corridor," in the narrow sense of the word, usually means the depressed area along the northeastern margin of the Nan-Shan mountain structure; it is occupied by a heavily populated and cultivated zone. The northeastern boundary of the zone is poorly defined; the zone gradually merges with the semidesert and desert area situated still farther to the northeast.

The geographical designation "Kansu Corridor" is of great antiquity (the Kansu Corridor has long been one of the most suitable routes of communication between central and western China), but it does not reflect the geological peculiarities of the area in question. The author has attempted to divide this region into large structural complexes. Some of them are situated in the Kansu Corridor and in its immediate vicinity, while others are some distance away but are important to our understanding of a series of seismic-geologic peculiarities in the entire zone. Below we give a brief description of these complexes.

1. The western part of the region is occupied by the mountain structures of the Nan-Shan and the Kuku-Nor. This territory in Paleozoic times formed a geosynclinal region, but at the end of the Paleozoic it experienced intensive folding; it was then transformed into a platform, which in the course of the Mesozoic and a large part of the Paleocene was characterized by general weakness of tectonic movements and a generally slightly uplifted position. At the end of the Paleocene or in the Neocene extremely sharp tectonic movements began, coinciding in time with similar movements in many regions of Central Asia: they are still continuing.

The intensity and regional character of these movements is such that we cannot examine them as distinctive platform structures. It is evident that a rearrangement of earlier existing platform structures has occurred here. Different geologists have different opinions as to the structural position of the young Neocene-Quaternary mountains of Asia that arose in this manner, but in the case at hand this is of no great importance.

To the northeast the Nan-Shan breaks off in a steep scarp with a local relief as great as 2 km (or somewhat greater). The central parts of the mountains (which we were able to visit), including the region of Lake Kuku-Nor, are characterized by relief that is little dissected; there are extensive and well preserved ancient peneplanes.

2. The mountain structure of the Nan-Shan drops down and sinks in a southeastern direction, somewhat to the north of the city of Lan-chou. There is a system of low Paleozoic ridges on its right extension; as far as we can judge from geologic maps at a scale of 1:500,000, they maintain the former Nan-Shan orientation (that is, generally northwest-southeast). This orientation can be followed to the meridian of Hai-yuan, or a little farther to the east, and is about 170-200 km in length from northwest to southeast. Provisionally we will call it the Tintay-Hai-yuan zone of folding, or the Tintay-Hai-yuan zone (Tintay and Hai-yuan are villages situated in the western and eastern parts of this zone, respectively).

There is little doubt that in Paleozoic times the Tintay-Hai-yuan zone formed a single unit with the Nan-Shan geosyncline and together with the Nan-Shan experienced folding at the end of the Paleozoic and was transformed into a platform. However, whereas in the Nan-Shan the platform stage of development ceased in the Neocene, in the Tintay-Hai-yuan zone it is still probably continuing; this statement is based on the general insignificance of the recent tectonic movements, the poor development and shallowness of Tertiary sediments, and the exceptionally low degree of general dislocation. The Tertiary rocks are usually disturbed only in the immediate vicinity of the Paleozoic ridges; some distance from these ridges they often have an almost horizontal position for a considerable distance; an example of this is seen along the banks of the Hwang-Ho in the vicinity of the city of Sinyuan (the general character of this zone is highly reminiscent of many sections of the Kazakh folded area).

Therefore there is basis to set apart the Tintay-Hai-yuan zone as an independent structural complex, regarding it as part of a once far more extensive platform whose folded basement was formed at the end of the Paleozoic; that is, it may be regarded as the still preserved part of an epi-Hercynian platform. The area around Lan-chou also probably belongs to this same zone.

3. The zone situated to the northeast of the Nan-Shan, on the extensive plains of the semidesert and desert of the Autonomous National Okrug of Ninghsia, is part of an ancient platform with a Pre-Cambrian folded basement which extends from the Sea of Japan to Sinyuan. That part of it which we are discussing is called the Ala-Shan massif.

The intensity of the tectonic movements of Neocene-Quaternary times is generally very insignificant here; intense movements evidently did not occur here over an exceedingly long period of time — from the beginning of the Paleozoic or from the Proterozoic. The platform conditions in the Ala-Shan area have evidently been preserved without substantial changes through many geologic periods.

4. Between the Ala-Shan massif, with its platform character, and the mountain structures of the Nan-Shan, approximately between Wu-wei and Shan-tan and farther to the northwest, parallel to the edge of the Nan-Shan, there is a system of small folds, topographically expressed as low ridges. Geologists differ as to their structural position; some believe that they are part of the Nan-Shan, while others consider them to be part of the Ala-Shan.

There is sound basis for the second point of view. At absolute elevations of 3-4 km and more in the Nan-Shan there is a widespread development of Paleozoic deposits of various ages, from the Lower- to the Upper Paleozoic. In the low ridges of the Wu-wei - Shan-tan zone, however, at absolute elevations up to 2 km or a little more, there are no surface exposures of Upper Paleozoic and Mesozoic rocks, contrary to what one might expect if we consider that these folds belong to the Nan-Shan and assume that they slope downward in a northeasterly direction. These ridges show a rather extensive development of very ancient formations — Archean and Lower Paleozoic, which in case the Wu-wei - Shan-tan zone belongs to the northward dipping slope of the Nan-Shan, should lie at greater depths.

Here and there in these ridges there are beautiful examples of peneplanes; this doubtlessly is evidence that there has been rather long stability in its uplifted position and that the tectonic movements that have occurred here in recent times were of little intensity.

The information given here is not direct proof, but when considered as a whole, it enables us to surmise that the Wu-wei - Shan-tan zone probably belongs to some other structural complex than the Nan-Shan. This problem is of great importance if we are to understand the interrelationship between seismic and geologic phenomena in this zone, because our problem is the determination of the nature of the connections between two such major structural complexes as the Nan-Shan and the Ala-Shan.

Until this problem is finally solved, it is best to ascribe to the Wu-wei - Shan-tan zone the role of an intermediate, transitional link between the Nan-Shan and the Ala-Shan, characterized by considerable singularity in structure and meriting delineation as an independent structural unit (although to a limited extent and on a provisional basis).

5. Along the eastern margin of this region, along its boundary with the ancient platform of the Ordos massif, there is a system of folded structures that has a general north-south orientation; these structures include both ancient rocks (Archean, Proterozoic, Paleozoic), and very extensively developed rocks of Mesozoic-Triassic, Jurassic and Cretaceous age. On the north this north-south folded system is called the Holan-Shan, while on the south it is called the Liupan-Shan — which probably can be considered an extension of the first.

It has not been precisely determined just where this zone belongs structurally. Evidently it may be regarded as a zone of radical rearrangement of an epi-Proterozoic platform which existed here at an earlier time and completely covered the Ordos-Ala-Shan area. Some believe that this zone has a very ancient tectonic character; this permits it to be delimited as a structure of the intermediate type, called a parageosyncline.

Of unquestioned importance is the tectonic mobility of the Holan-Shan - Liupan-Shan zone; this is expressed in rather deep and prolonged subsidence (over the greater part of the Mesozoic) which occurred over a rather extensive area. This zone was subjected to folding at the end of the Mesozoic and subsidence was replaced by uplift which continued at a later date. The absolute elevations in the Holan-Shan are considerable -- up to 3,500 m.

Although the Holan-Shan - Liupan-Shan zone is situated far from the Kansu Corridor proper, a study of the peculiarities of its structure and relationships with the Tintay-Hai-yuan folds, can be, as will be seen later on, very important for our understanding of the seismic-geologic conditions of the Tintay-Hai-yuan zone.

Data Concerning the Seismicity of the Region

This region is one of the most highly seismic zones in China. Two extraordinarily severe earthquakes, with intensities of 11-12, occurred within its boundaries -- in 1920 and 1927.

The first, according to Gutenberg's data, was among the world's 26 severest earthquakes in the 52 year period between January 1904 and July 1956; its intensity m (unified magnitude) was 7.9. Still another earthquake, with an intensity exceeding 7 3/4, occurred in 1739 in the southern part of the Holan-Shan.

Other than these earthquakes of maximum intensity, this area is the site of the epicenters of many other earthquakes, including catastrophic ones, recorded by seismic stations or known from historical records. They are all shown on the map of earthquake epicenters of the Chinese People's Republic, drawn up at the Institute of Geophysics and Meteorology of the Academy of Sciences of the Chinese People's Republic under the direction of Li Shan-pan [part of this map is contained in the original text].

The general characteristics of seismic activity in this area, pertinent to the large structural complexes which have been briefly described above, are given below. First of all it should be emphasized that existing statistical data relative to seismicity gives evidence of very great differences in the degree of seismicity in different parts of this area.

The Nan-Shan and Kuku-Nor Ranges. Earthquake epicenters are very unevenly distributed in this area. The map shows that there is a more or less fixed zone in which the epicenters are situated; the zone extends northwest-southeast along the boundary between the Nan-Shan and the plains and low mountains situated to the northeast. The epicenter of the catastrophic earthquake of 1927 is also situated in this zone.

It is still not clear whether all the epicenters of this zone are related directly to the joining of the Nan-Shan with the structures situated to the northeast of it. Probably part of the earthquakes are caused by movements in the Wu-wei - Shan-tan tectonic zone, which is transitional between the Nan-Shan and the Ala-Shan.

The indicated zone of epicenters, with a southeast-northwest orientation, also continues to the south of the area in which part of the Nan-Shan, gradually sinking, passes into the folds of the Tintay-Hai-yuan zone. There is a group of epicenters to the northwest of Lan-chou, constituting the extreme southern link of this seismic zone (within the limits of the area under consideration). Epicenters are also found in the vicinity of Lu-tias, to the southwest of Lan-chou.

It is extremely interesting that in the high-mountain areas, with their extensive development of peneplanes, there are by far fewer earthquake epicenters than in the foothill zone. In the Nan-Shan itself, within the limits of the area examined, they are completely absent; in the Kuku-Nor there are several epicenters for what have been predominantly low-intensity earthquakes. These epicenters are all situated in the eastern part of the Kuku-Nor.

The composite map of the epicenters of China is quite imperfect (the maximum number of errors is to be found in the mountain regions of the remote provinces), but much of the information is correct. There is no doubt that to a certain extent it reflects the true picture of the distribution of earthquake epicenters.

Tintay-Hai-yuan zone. Earthquake epicenters are also distributed unevenly here. In the western part of the zone there are three epicenters whereas in the eastern part the density of epicenters is even greater than along the northwestern boundary of the Nan-Shan. At this point it should be noted that on the whole the intensity of earthquakes in the Tintay-Hai-yuan zone is greater than in the Nan-Shan zone. In addition to the extremely intense earthquake of 1920 several other earthquakes have also been recorded whose intensity, according to the composite map of the epicenters of China, was in the range of 7 to 7 3/4.

The distribution of epicenters discloses no general pattern (other than that there are fewer in the western part of the zone and more in the east); they do not form a single elongated zone, as along the Nan-Shan, but are scattered in groups. There are also isolated epicenters.

Ala-Shan massif. There is only one epicenter of a rather weak earthquake (39°05' N., 104°15' E.) shown on the composite map of the earthquake epicenters of China; it is in the Ala-Shan area. However, Chinese seismologists have informed us that refined data show that a considerable number of earthquakes have occurred here since 1920. This is especially true of the area of Min-ch'in, where an earthquake of intensity 8 occurred in 1954. Following this quake there were many less intense shocks, whose epicenters form a compact group. Individual epicenters are also found far to the north, in various parts of the Ala-Shan massif.

Wu-wei - Shan-tan zone. As mentioned above, a number of epicenters at first glance situated along the northeastern margin of the Nan-Shan, in all probability belong to the Wu-wei - Shan-tan tectonic zone. If we place our entire trust in the composite map of the epicenters of China, then nearly all the epicenters situated to the northwest of Shan-tan must belong to this tectonic zone. It is possible, however, that part of them have been inaccurately determined and in actuality belong in the Nan-Shan zone. Other, apparently, belong in the Wu-wei - Shan-tan zone. In particular this is probably correct in respect to the destructive Shan-tan earthquake of 1954 which reached an intensity of 8-9 in the epicentral region.

Holan-Shan - Liupan-Shan zone. Very conspicuous is a dense group of epicenters of different intensity, situated, judging by the map, on the plain in the vicinity of the city of In-ch'uan. If they have in fact been determined correctly, the manifestation of such a pronounced seismicity in an area where the relief is quite subdued is a matter meriting close examination.

In this same region, but somewhat farther to the north, we find the epicenter of the very strong earthquake of 1739, whose intensity is shown on the map as exceeding 7 3/4.

Several earthquake epicenters are known to exist in the sector where north-south structures are developed; they are in the extreme southern part of this zone (beyond the boundaries of the area examined).

Concerning Several Problems of the Relationship Between Seismic Phenomena and Geological Conditions

For several sections of the described area the relationship between seismic and geologic phenomena evidently can be discovered relatively easily, although it should be emphasized that we are of course referring only to the most general approximation. Included here is the seismic zone along the north-eastern margin of the Nan-Shan, probably associated with movements along the zone of juncture of this young rising mountain massif and the structures situated to the northeast; the latter have experienced far less uplift, and in places — relative subsidence.

The small number of earthquakes within the Nan-Shan and Kuku-Nor Ranges themselves is quite well understood, inasmuch as these mountain structures are experiencing general uplifts -- but very recent contrasting tectonic movements are evidently absent. These regions are characterized by a very extensive development of peneplanes.

The relative recentness of the folding of the Holan-Shan, as well as the quite considerable intensity of the most recent movements, gives us reason to believe that these geological phenomena are the cause of the increased seismicity of the region in question.

For other regions the relationship between geologic and seismic phenomena (even in the most approximate way) cannot be discovered without special research. Such regions include the plains and modified plains of the Ala-Shan area; earthquakes sometimes occur there despite the completely apparent weakness of very recent tectonic movements. If the region of Min-ch'in is also part of this tectonic zone (which seems most probable), then a considerable number of earthquakes apparently occur within its boundaries -- some of them of great intensity.

Of still greater interest is the Tintay-Hai-yuan zone, site of the very intense earthquake of 1920 and a number of other shocks that were weaker, but also of considerable intensity. This zone, as mentioned above, may be regarded as a still-preserved part of a once far more extensive epi-Hercynian platform. The platform structures, as a rule, are not highly seismic, provided that significant tectonic movements have not occurred in the past and/or are not occurring at present, which have led or are leading to structural changes, although the region as a whole has continued to be a platform (an example is the seismically active system of grabens formed in the zone of great African rifts in the heart of the African platform).

Such movements are not observed in obvious form on the Tintay-Hai-yuan platform, but there is a sharp increase in seismicity. The geologic causes of this phenomenon are presently a matter of pure conjecture. Rather than discuss this matter it is better to devote attention to several facts already noted earlier in this article — above all to the fact that in the western part of the Tintay-Hai-yuan zone of epicenters there are notably fewer earthquakes than in the east. It appears that as we approach the mountain structures of the Nan-Shan, for which there is absolutely no doubt as to the intensity of very recent tectonic movements, the number of earthquakes decreases (or, expressed differently, the activity of present-day tectonic movements decreases). This very interesting phenomenon, contradicting our ordinary concept of the relationship between seismicity and geological conditions, should be the subject of special study in the future.

There appears to be no fixed pattern in the location of the epicenters of this zone. They do not form zones with a fixed orientation which could be associated with some deep structure -- of Nan-Shan orientation, if this zone was northwest-southeast -- or Holan-Shan, if it were oriented north-south. I mention these two directions because it would seem easiest to explain the seismicity of this zone by movement along the lines of orientation of the Nan-Shan (because the Tintay-Hai-yuan zone was earlier an integral part of the Nan-Shan), or along a north-south line (along a possible boundary with the north-south Holan-Shan structures).

Nevertheless, in expressing hypotheses relative to the geologic causes for the increase in seismicity in the eastern part of the Tintay-Hai-yuan zone, the author feels it impossible to ignore the possibility of considerable tectonic movements in connection with a sharp change in the overall structural picture as we move eastward from Hai-yuan. It is probably impossible to exclude the possibility that the structures of the Tintay-Hai-yuan zone, oriented northwest-southeast, are not extinguished eastward, toward the north-south Holan-Shan - Liupan-Shan zone, but intersect or truncate it. Taking into account the unquestionably younger age of the second of these zones, we must consider that this intersection, if it took place, occurred in relatively recent geologic times, with resultant continuation of tectonic movements in this area. It is well known that areas with sharp changes in the structural layout are often seismically active.

The second hypothesis, which seems to me more probable, involves the following. Several dozen kilometers to the north of Hai-yuan, where the mantle of loess is discontinuous (in the vicinity of Chungning), it is easy to see that the drainage net is poorly incised.

As we move southward, simultaneously with an increase in the development of the loess mantle, which then becomes continuous, there is a marked increase in the depth to which the drainage net is incised. This, to be sure, is due to the existence of an easily erodable loess cover, but can also in part be caused by the greater tectonic mobility of this region, whose traces are masked by the deep and continuous loess cover of the Hai-yuan region. It is not impossible that in contrast to the regions directly adjoining to the north, the Hai-yuan sector is characterized by numerous very recent (Quaternary) differential tectonic movements, leading to uneven shifting of small blocks.

Other hypotheses can be made on this problem but none of them will have sound bases until there are special seismic-geologic investigations. There is no doubt that a study of the geologic causes of the earthquake of 1920 and the relationships between seismicity and geological conditions in the entire Tintay-Hai-yuan zone is of exceptional interest, although an extremely difficult task.

An understanding of the peculiarities of the seismicity of the Wu-wei - Shan-tan zone will depend to a great extent on the determination of its structural position. In case it belongs to the Ala-Shan we can assume that the juncture between the Nan-Shan and the Ala-Shan is very sharp; as a result we must count on the possibility that there will be a rather frequent occurrence of very intense earthquakes. Northward the number of earthquakes should evidently decrease rapidly.

If, however, the Wu-wei - Shan-tan zone belongs to the Nan-Shan, we can assume that its juncture with the Ala-Shan is less sharp; this makes it less probable that there will be a significant number of very strong shocks here. On the other hand, in this latter case we should expect the earthquake epicenters to be situated quite far to the north of the northern edge of the Nan-Shan mountain system.

This problem can only be solved after appropriate investigations have been made.

General Remarks

In the example provided by this region we encounter a situation in which there is considerable dissimilarity in the relationships between seismic and geologic conditions. This situation, repeatedly observed in seismic-geologic work in the most varied regions of the USSR, proves to be characteristic of the Kansu Corridor as well.

In this region, as in almost all seismic regions of the USSR, the zones where there are intense and very recent tectonic movements morphologically expressed (in the relief), do not coincide with areas where there is a sharp increase in seismicity. On the other hand, some highly seismic sectors of the Kansu Corridor are situated in regions where geomorphological data indicate that the very recent movements are weak. An example is the epicentral region of the earthquake of 1920.

Turning to the plan for investigation of the seismicity of the Kansu Corridor, it should be noted that Chinese seismologists have wisely selected it as an object for priority study. Geologically it is a varied and complex region structurally; its seismicity, evidently associated with a number of factors, is also considerably different in its various parts. Taken as a whole, these circumstances make the task of research especially difficult but exceptionally interesting and important because it is under such conditions that we can count on getting the most varied and many-sided data concerning the character of seismicity.

The study of the seismicity (including seismic-geologic conditions) of the Kansu Corridor can be successful only if it is carried on over the entire area. We have seen that four of the five delimited large structural complexes (Nan-Shan zone, Tintay-Hai-yuan zone, Ala-Shan zone, Wu-wei - Shan-tan zone) are closely connected with one another or are interrelated in such a way that it is impossible to study one or more of them without studying the others. Only after the joint investigation of these complexes can we hope that their seismic-geologic peculiarities will be correctly understood, in particular those significant differences in degree of seismic activity which become clear from study of seismic-statistical data.

It is not difficult to see that although the Holan-Shan - Liupan-Shan zone is rather distant from the Kansu Corridor proper, it is absolutely necessary to study it. It is not impossible that after clarifying the character of its relationship with the Tintay-Hai-yuan zone we will be able to understand the geologic causes of the sharp increase in the degree of seismicity in the Hai-yuan area.

Seismic-geologic research in the region examined should shed light on the geologic development of the large structures in the area and their relationship to one another, both at the present time and in past geologic time. A comparison of these data with seismic-statistical data should enable us to note the geological criteria of seismicity for this region; this will be of considerable importance when compiling maps of seismic regionalization and when accumulating experience for planning such work in other regions of the Chinese People's Republic. These investigations are extremely important in theoretical respects as well.

The great extent of the area under investigation did not permit us to begin research simultaneously over the entire area. Probably research should begin in the best studied and most accessible area; then, after its seismic-geologic peculiarities have been explained and researchers have accumulated experience in this particular kind of work, research should be initiated in the next region. The best place in which to conduct work in 1959 will be that area selected by Chinese seismologists for the establishment of regional seismologic stations in that year; the area is shaped like a triangle with the corners at Hulan, Min-ch'in and Shan-tan. The adjoining areas of the Nan-Shan should also be added to this region.

Subsequently the area should be expanded both to the west and to the east, right up to the Holan-Shan and the region of In-ch'uan. Research work can later progress southward, to the Tintay-Hai-yuan zone. In the process there will be an increase in the number of temporary seismic stations.

It is probable that there then will arise a need for a brief investigation and intercomparison of the seismogeology of a number of other seismic regions located not far from the region examined. Reference is made to the more westerly regions of the Nan-Shan (the Richthofen Range), the Tsingling mountain system and the regions to the east of Sian.

Inasmuch as the Institute of Geophysics and Meteorology for the time being still has no experience in seismic-geologic work, it is expedient to devote 1959 to the accumulation of such experience as the seismologists of the Kansu expedition will accumulate in the organization and conduct of regional research.

In conclusion it should be noted that the work planned by Chinese seismologists in the immediate future for the study of the seismicity of the Kansu Corridor means the beginning of a new stage in seismological research in China. From generalized work whose results could be presented only in schematic form and at a small scale, Chinese scientists are moving on to detailed research on the regional seismicity of their country. In so doing they are setting themselves the task of performing well-rounded research for the solution of both purely seismological and seismic-geologic problems. The experience of such work, conducted in recent years in the USSR by the Institute of Earth Physics, shows that the success of this work can be guaranteed to a very considerable extent by well-rounded research by geophysicists and geologists working together. This has been pointed out repeatedly by G. A. Gamburtsev. The generally high level of Chinese science leaves no doubt that in problems of study of regional seismicity Chinese scholars will soon report new, important, and interesting results.

I consider it my pleasant duty to thank the directors of the Institute of Geophysics and Meteorology of the Academy of Sciences of the Chinese People's Republic for their excellent organization of the work of our group during our stay in China. In this connection I would especially like to mention the Deputy Director, Chen I, Professors Li Shan-pan, Fu Chen-i, Se Yu-shu, and an associate of the Geological Institute, Professor Siu Yu-tsien. We are also grateful to our young Chinese comrades, seismologists and geologists, who were our companions on our trips and participants in our discussions; they always showed the liveliest interest in their work and attentively adhered to our advice. ("A Contribution to Research on Seismicity in the Chinese People's Republic, by B. A. Petruzhevskiy, Izvestiya Akademii Nauk SSSR, Seriya Geofizicheskaya, No 12, Dec 1959, pp 1729-1738. /Editor's note: The names of the Chinese scientists mentioned in this article have not been confirmed and are only loosely transliterated./)

The Relationship Between Seismic Activity and Structural Geology on Kamchatka and in the Kuriles

New data has become available concerning the Kurile-Kamchatka seismic zone; it is based on observations made by seismic stations in the USSR over a long period.

Earlier researchers pictured the tectonic structure of Kamchatka and the Kurile Islands in the form of a single system of linear anticlinal and synclinal structures; this concept has now been modified.

The development of a network of seismic stations in the Far East, together with improved methods for processing seismic observations, have made it possible to more precisely determine the principal seismic elements in the earthquakes of the Kurile-Kamchatka chain (the coordinates of the epicenters, the depths of the foci, intensity, etc.); this has resulted in a refined and elaborated map of seismicity for the area.

This article uses the results of seismic observations in the period 1954-1957 and data relative to earthquakes with an intensity greater than 7, with the epicenters determined with an error no greater than 50 km.

Increasing efforts have been made to correlate the sites of earthquakes to geological structures on the peninsula and on the islands; these efforts have met with much success.

It now seems clear that the Kurile-Kamchatka seismic zone is broken into a series of transverse groups of high and low seismicity, within which the belt of most intense earthquakes has a north-south and northwest-southeast orientation.

Detailed textual data expands on the points given above and there is a new and significant schematic map of seismicity in the Kurile-Kamchatka area. ("On the Problem of Seismicity and Structural Geology of Kamchatka and the Northern Part of the Kurile Range," by I. V. Kondorskaya and V. I. Tikhonov, Doklady Akademii Nauk SSSR, Vol 130, No 1, 1960, pp 146-148)

VI. OCEANOGRAPHY

Quantitative Distribution of Bottom Fauna in the World Ocean

Data concerning the quantitative distribution of life in the ocean is of very great significance for the development of the sciences of oceanology. This information is necessary to clarify the patterns of distribution and regeneration of living resources in the ocean, for an understanding of the trophic relationships between organisms, for a description of the living organisms of the halosphere as an indicator of physical processes, and for understanding the role of living organisms in the cycle of chemical substances in the ocean. All these phenomena require numerical expression, or they lose a large part of their scientific and practical value. It is well known that living organisms are able to accumulate various chemical elements in their bodies, including radioactive elements, in amounts a thousand times greater than the concentration of these elements in the waters of the ocean. It is now therefore especially important to acquire quantitative data relative to life in the ocean because of the present day problem of dissemination of radioactive fallout in the ocean.

In respect to organisms in the ocean, we must agree with G. Torson when he advocates the need for quantitative mapping of the fauna of the ocean bottom by use of a single standard research method. But until now such research has been conducted in only a few regions, predominantly in the Arctic and along the coast of Western Europe. Torson notes that little work of this type has been done in the United States. It might be added that this reproach cannot be directed against the USSR; such research has been carried on for over 35 years in the seas surrounding the Soviet Union.

During the last ten years expeditions on the ships Vityaz' and Ob' have collected data on the distribution of benthos not only near our own shores, but in the Pacific, Indian and Antarctic Oceans as well. Only a limited amount of this data has been published up to now /original article contains a bibliography/.

This article contains a map showing the quantitative distribution of bottom fauna in the Pacific and Indian Oceans. The map is based on data resulting from bottom samplings made from aboard the Vityaz' and Ob' up to April 1959; these samplings were taken from depths greater than 2,000 m at more than 2,000 "stations." This map enables us to judge for the first time (although roughly) the quantitative distribution of benthos in an area taking in more than one quarter of the area of the Pacific Ocean.

The map shows that the maximum amounts of deep-water bottom fauna are found in coastal regions. As one goes away from the shore one observes a quantitative decrease in the abundance of bottom fauna. Poorest in such life are the tropical zones of the ocean distant from coastal regions.

Currently available data on the quantitative abundance of zoobenthos in the various regions of the world ocean enable us to make rough calculations of the total amounts of bottom fauna in the entire ocean. These data refer to the area of ocean surface, without taking into consideration irregularities in the relief of the ocean bottom. As a result, the area actually populated by bottom fauna should be somewhat greater than the values given in the table below. Considering this and other factors, the total supply of benthos in the entire ocean, 6,660 million tons, should be increased by $1\frac{1}{2}$ times. Of the total amount, more than 80% is to be found in shallow coastal waters and less than 1% in the abysses which constitute more than 3/4 of the area of the world ocean.

 Table

Amount of Bottom Fauna in the World Ocean

Depth, m	Area millions km^2	Area %	Approximate average biotic mass, g/m^2 (t/km^2)	Total biotic mass million tons	Total biotic mass %
0-200	27.5	7.6	200	5500	82.6
200-3000	55.2	15.3	20	1104	16.6
>3000	278.3	77.4	0.2	56	0.8
Entire ocean	361	100	18.5	6660	100

("Quantitative Distribution of Bottom Fauna in the Depths of the World Ocean," by L. A. Zenkevich, N. G. Barsanova and G. M. Belyayev, Doklady Akademii Nauk SSSR, Vol 130, No 1, 1960, pp 183-186)

VII. GLACIOLOGY

Traces of Upper Pliocene Glaciation in the Central Caucasus

The problem of Upper Pliocene glaciation is one of the most disputed problems of the paleogeography of the Caucasus. Some researchers point to definite evidence that it existed, while others question or deny such evidence. Many have felt that glacial and erosional processes have removed any such evidence that might have existed.

During geological field work in 1956-1959 in the high mountains of the northern slope of the Caucasus a number of places were found with traces of moraines associated with very ancient glaciation; these sites were at elevations of 2.5-3.5 km.

The field party made a detailed investigation of all geological and geomorphological phenomena at the site and carefully studied the morainal material. Much information was derived and the glacial debris was judged to date from the Upper Pliocene. This supports the claim that Upper Pliocene moraines are also present in the northern foothills of the Caucasus and provides evidence that glaciers existed in the Caucasus Mountains in that era. ("Concerning Traces of Upper Pliocene Glaciation in High Mountain Parts of the Central Caucasus," by Ye. Ye. Milanovskiy, Doklady Akademii Nauk SSSR, Vol 130, No 1, 1960, pp 158-161)

The Fifth Antarctic Expedition Begins its Work

 A radio dispatch from Mirnyy on 2 February 1960 reports as follows: "Late yesterday evening the expeditionary ships Ob' and Kooperatsiya set sail for the Motherland. Aboard these ships were the participants in the Fourth Antarctic Expedition. The flag of the Fifth Antarctic Expedition has been raised on the flagstaff at Mirnyy. At the moment of the solemn ceremony the majestic sounds of the national anthem echoed far into the surrounding expanses of ice; salvoes thundered from rocket launchers and the burst of this salute stood out brightly against the dark blue sky." ("The Fifth Antarctic Expedition Begins its Work," Pravda, 3 February 1960, p 6)

Somov Reports on Soviet Victories in Antarctica

M. Somov, Hero of the Soviet Union and Doctor of Geographical Sciences, gives a review of Russian Antarctic activities in an Izvestiya article of January 29.

"The International Geophysical Year," says Somov, "was a bright event in the history of Antarctic study. During a relatively short period of time humanity has learned more about Antarctica than it did during all its preceding history -- and Soviet researchers played an important role in this work."

"The task of Soviet oceanographers," he adds, "is the study of thermal exchange between Antarctic waters and the atmosphere and with the waters of adjoining parts of the world ocean. The expeditions have studied the dynamics and chemistry of these waters, the flora and fauna living therein, and the morphology and geological structure of the ocean floor. Soviet researchers have solved a whole series of problems -- for example, they have convincingly demonstrated the danger of dumping atomic debris in deep water depressions.

"Only now have scientists been able to compare the complex phenomena transpiring at the two poles of that great magnet, the Earth. The way is now open to discover the mechanism of many hitherto unexplained phenomena observed in the Earth's magnetic field.

"Several seismic stations are now in operation. The Soviet stations have recorded more than 1,000 earthquakes, some of which have been recorded only on instruments in Antarctica.

"Until recently it was believed that the strong westerly winds blowing in the high south latitudes blocked off Antarctica, excluding its climatic influence on the remainder of the Southern Hemisphere. The reverse has now been shown to be true: the Antarctic plays an important role in the formation of the synoptic processes of the Southern Hemisphere.

"Antarctica is covered by a mantle of permanent ice, about 2 km thick — in places, 4 km. This ice contains more fresh water than is found in all the lakes and rivers of the globe. If these immense quantities of ice were to thaw, the level of the world ocean would rise by more than 50 meters.

"In the vicinity of Mirnyy repeated aerial surveys of the edge of the continental ice over a distance of 600 km have established that in the course of a year an average of 50,000 cubic meters of ice breaks off and floats into the sea in the form of icebergs.

"Interesting data have been collected relative to the retreat of the Antarctic ice sheet in the coastal zone since the turn of the century. For example, the glacier surface on Mount Gauss has dropped 8 meters since 1902 although the glacier's rate of movement has not changed. The level of the world ocean has risen by 6 cm during the last 50 years.

"The order of the day," he concludes, "is the practical utilization of Antarctica. In particular, the matter of Trans-Antarctic airlines is under discussion and the construction of permanent airfields is being planned. Future society, living under a planned economy and producing an abundance of food, may find Antarctica useful as a gigantic natural refrigerator." ("Attack on the Ice Continent," by M. Somov, Izvestiya, 29 January 1960, p 4)

Soviets Name Newly Discovered Ocean Trench

The name of Mikhail Lazarev, the great Russian naval commander and Antarctic explorer, was given to the deep, narrow trench off the coast of eastern Antarctica discovered recently by Soviet expeditions. The trench lies parallel to the edge of the continent for 2,000 miles. ("In a Few Words"; Moscow, Pravda, 5 Feb 1960, p 6)

US COMM-DC